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HS230 / HS130 SUPERCAPACITOR
Datasheet Rev 1.0

Features

- High capacitance (1200mF @ DC)
- Low ESR (50mΩ @ step change in current);
- High peak current
- High pulsed power
- Thin form factor

Typical Applications

- High power LED Flash
- Improved audio performance
- Automatic Meter Reading
- PC Cards, Compact Flash Cards & USB
- Load leveling for PDAs & cell phones
- Power support during battery contact bounce

Electrical Specifications

Table 1: Nominal Characteristics

Device	Nominal Capacitance[1]	Nominal ESR[2]	Tolerance about nominal value	Footprint	Height
HS130	2400mF	26mΩ	±20%	39mm x 17mm	1.85mm
HS230	1200mF	50mΩ	±20%	39mm x 17mm	3.80mm

[1]At 23ºC DC. [2]Measured using a 1A step in current @ 23ºC.

Table 2: Absolute Maximum Ratings

Parameter	Name	Conditions	Min	Max	Units
Terminal Voltage	Vc			5.8	V
Temperature	T		-40	+85	°C

Table 3: Electrical Characteristics

Parameter	Name	Conditions	Min	Typical	Max	Units
Terminal Voltage	Vc				5.5	V
Leakage Current[3]	I_L	5.5V, 23°C 72hrs		4.2	5	μA
RMS Current	I_{RMS}	23°C			4	A
Peak Current[4]	I_P	23°C			22	A

[3]Refer to CAP-XX for details. [2]Single pulse, non repetitive current.

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Definition of Terms

In its simplest form, the Equivalent Series Resistance (ESR) of a capacitor is the real part of the complex impedance. In the time domain it can be found by applying a step discharge current to a charged capacitor as in figure 2. In this figure the supercapacitor is pre-charged and then discharged with a current pulse (I). The ESR is found by dividing the instantaneous voltage step (ΔV) by I. The instantaneous capacitance (C_i) can be found by taking the inverse of the derivative of the voltage and multiplying it by I. The effective capacitance (C_e) is found by dividing the total charge removed from the capacitor (ΔQ_n) by the voltage lost by the capacitor (ΔV_n). Note that ΔV, or IR drop, is not included because very little charge is removed from the capacitor during this time. C_e shows the time response of the capacitor and it is useful for predicting circuit behavior in pulsed applications.

In the example of Fig 1, ΔV = 4.97V – 4.89V = 0.08V, I = 1.34A, so ESR = 0.08V/1.34A = 59.7mΩ. Similarly for a ΔV_n = 4.88V – 4.83V = 0.05V, Δt_n = 0.02s, and I = 1.4A. Therefore, C = 1.4A X 0.02s/0.05V = 560mF.

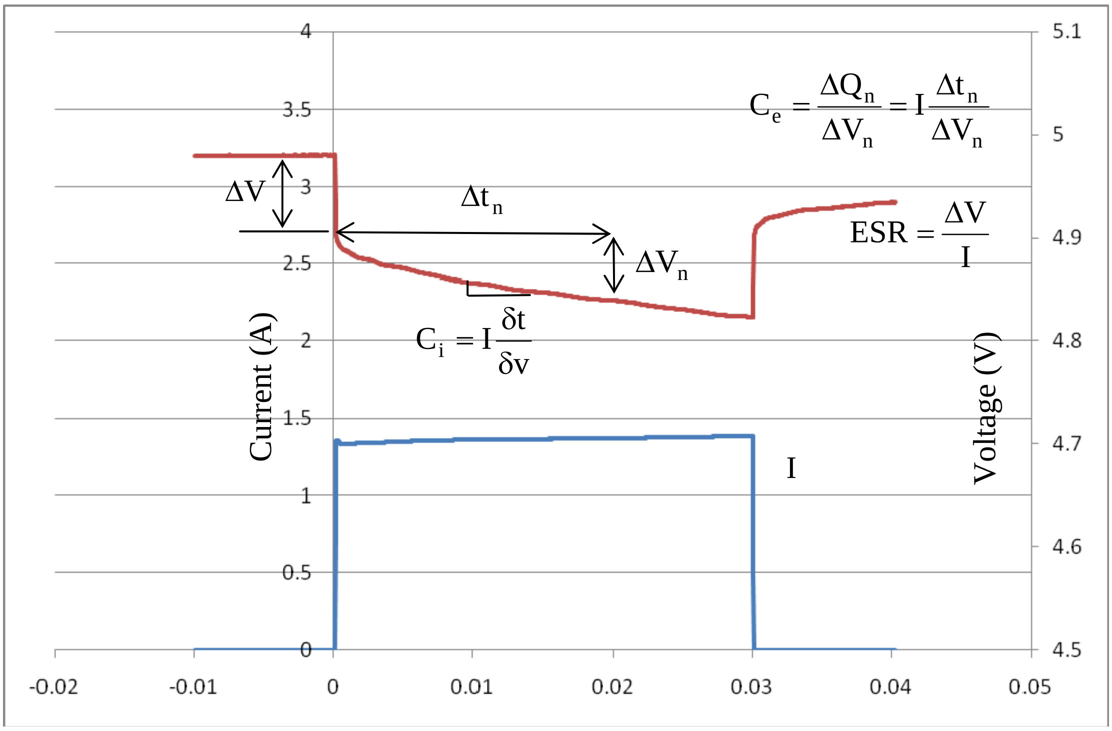

Figure 1: definitions for Effective Capacitance, Instantaneous Capacitance and ESR

DC Capacitance

CAP-XX measures DC capacitance by charging the supercapacitor to 4.5V then disconnecting the supercapacitor from the source, and applying a constant current discharge of 100mA. We measure the time taken to drop from 3V to 1V, so C = 100mA x time taken to drop from 3V to 1V/2V.

In the example of Fig 2, for a ΔV_n = 3.0V – 1.0V = 2V, the corresponding Δt_n = 22.52s – 11.72s = 10.8s. C = I X $\Delta t_n/\Delta V_n$ where I = 0.105A, therefore C = 0.105x11.2s /2.0V = 567mF.

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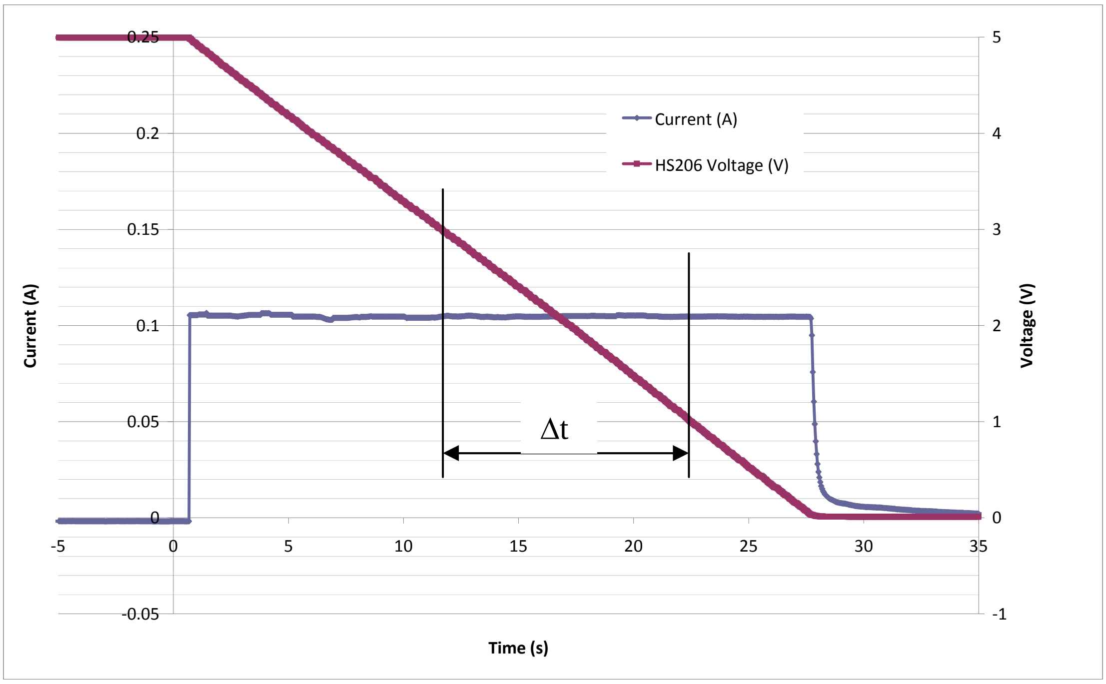

Fig 2: Measurement of DC capacitance

ESR Measurement

CAP-XX measures ESR by measuring the voltage drop across the supercapacitor when a current step is applied to a supercapacitor. The supercapacitor is first charged to 4.5V then disconnected from the source, and finally the current step applied and the voltage drop measured.

In the example of Fig 3 below ΔV = 4.98V – 4.90V = 80mV and ΔI = 1.33A (load pulse), therefore ESR = ΔV/I = 60mΩ.

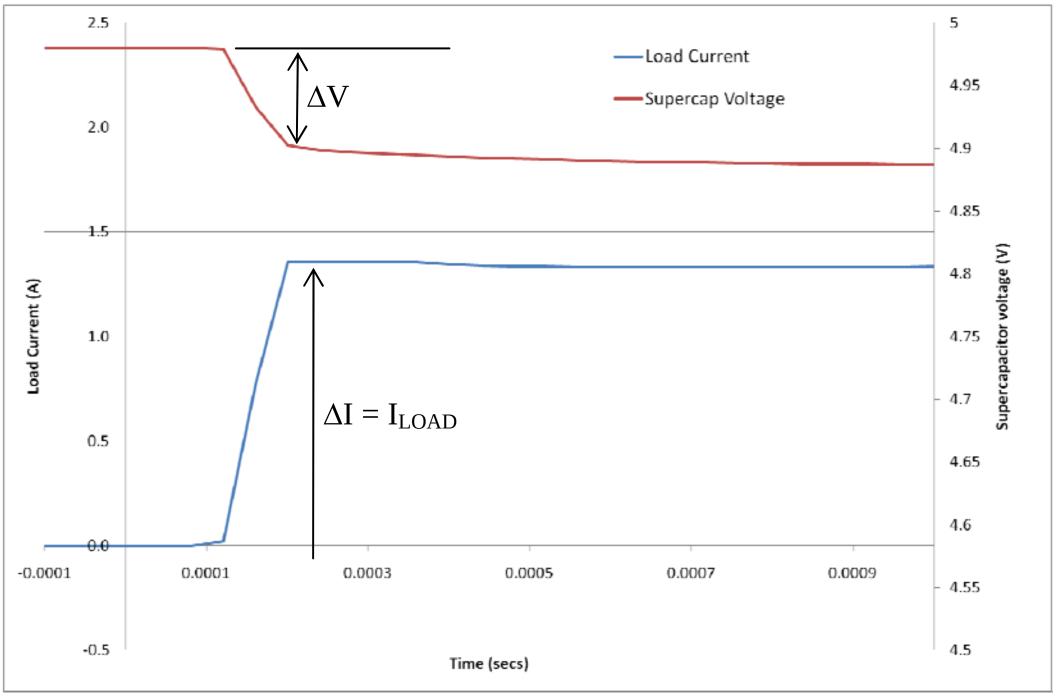

Fig 3: Measurement of ESR

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Effective Capacitance

Figure 4 shows the Effective Capacitance for the HS230 @ 23°C. The supercapacitor was charged to and held at 5.5V until the current drawn by the supercapacitor dropped to less than 100µA. The supercapacitor was then disconnected from the source and a constant current discharge was applied for 10 seconds.

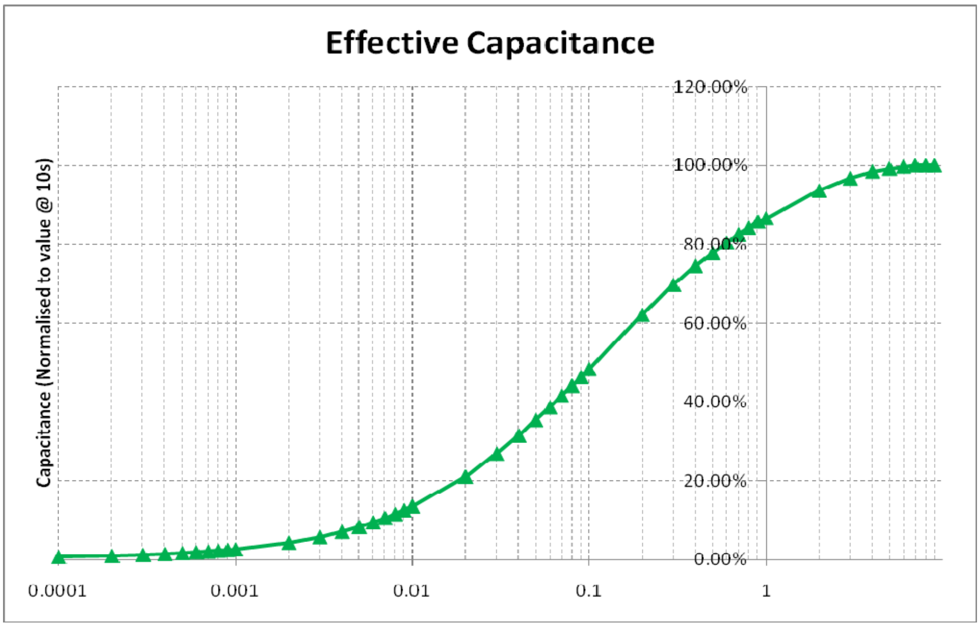

Figure 4: Effective Capacitance – charged to 5.5V and discharged with a current pulse

Pulse Response

Figure 5 shows the voltage ripple for a class 10 GPRS pulse. A HS230 provides a 1.8A load pulse of 1.15ms duration @ 25% duty cycle and the source current is limited to 500mA, though there is some source current overshoot evident in the first 100µs. The low supercapacitor ESR and high effective capacitance result in the load seeing a voltage ripple of only 125mV. The supercapacitor is supplying the difference between the 1.8A load current and the 0.5A source current.

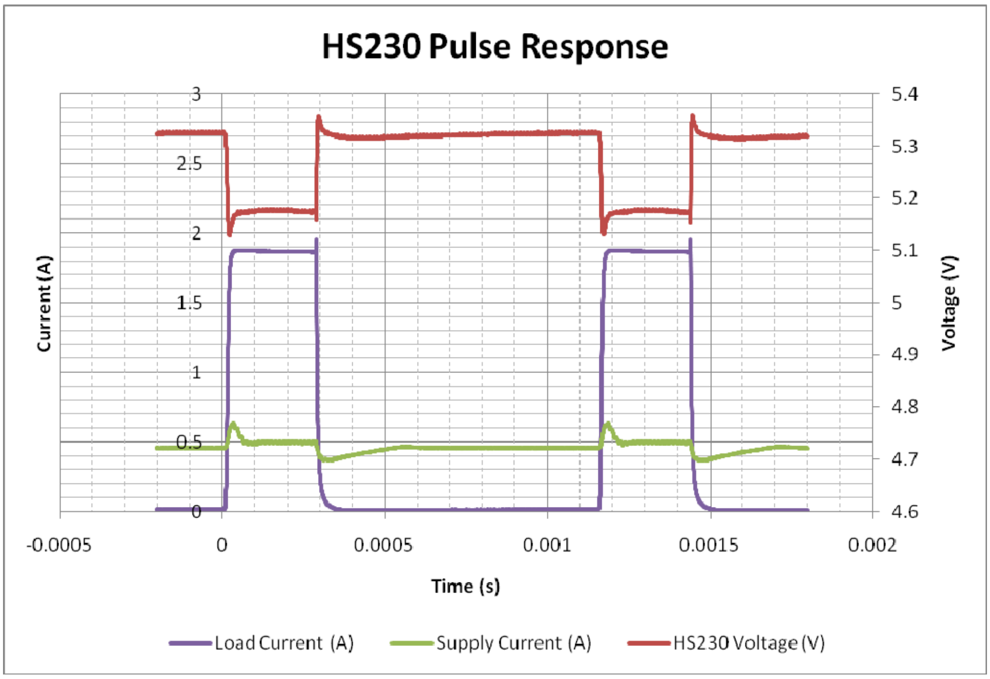

Figure 5: Supercapacitor voltage ripple for GPRS class 10 pulse with 1.8A peak load current

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Capacitance and ESR with temperature

Fig 6 below shows that DC capacitance varies minimally over the operating temperature range.

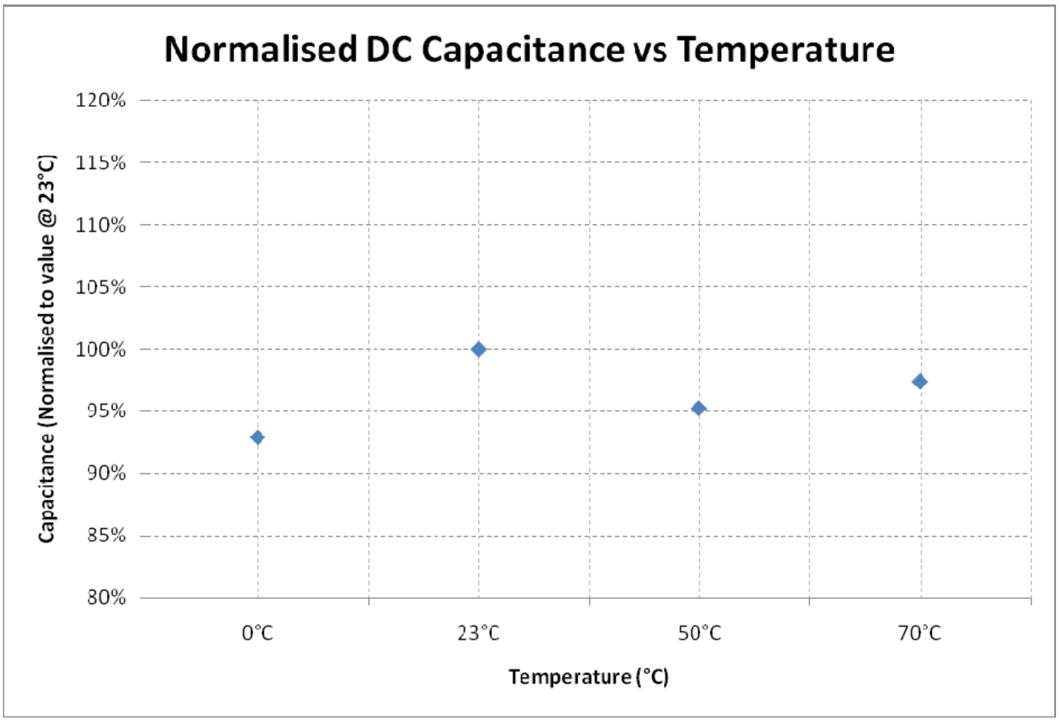

Figure 6: Capacitance change with temperature

Fig 7 shows the relationship between ESR and temperature. ESR at 0°C is ~120% of ESR at 23°C.

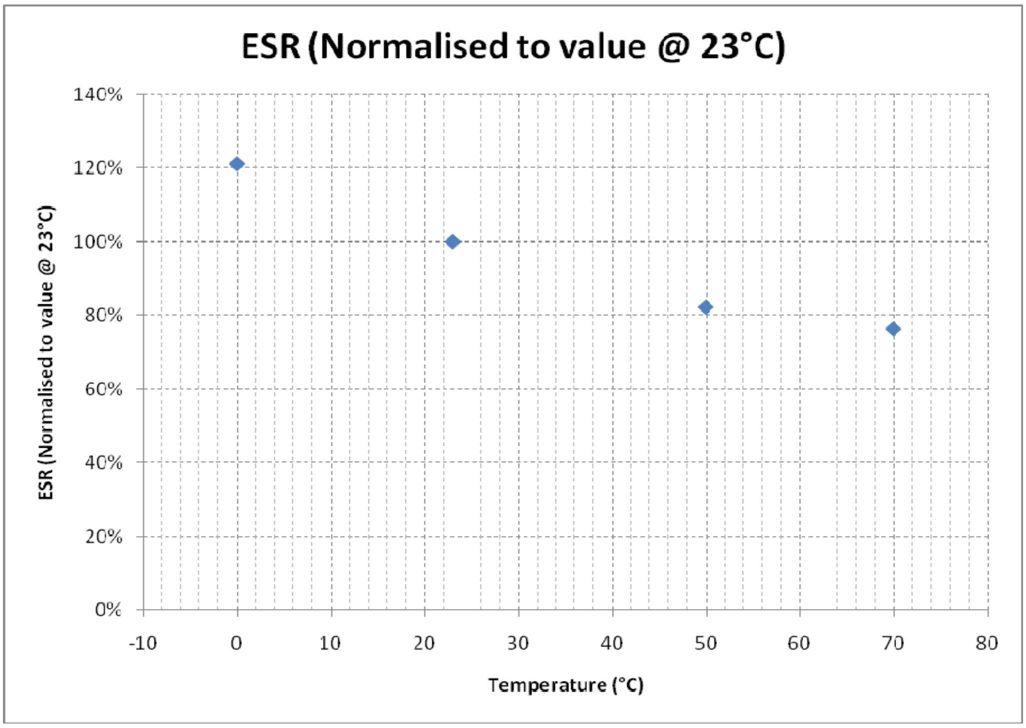

Figure 7: ESR change with temperature

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Frequency Response

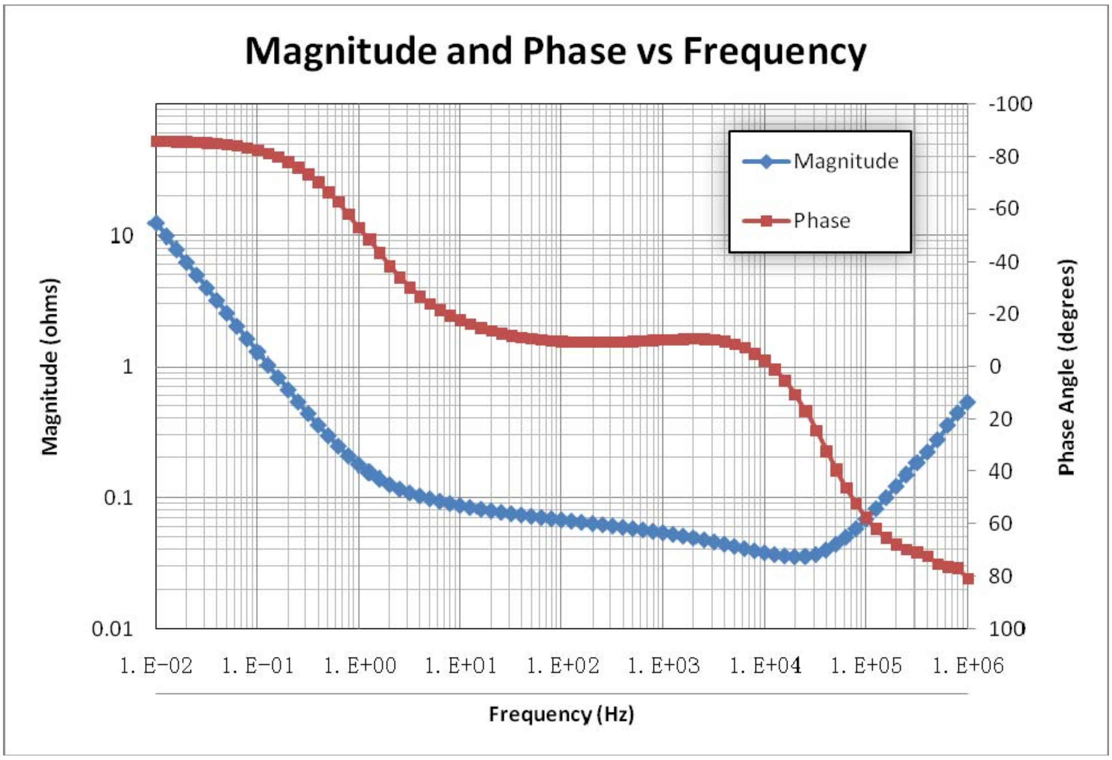

Figure 8: Frequency Response of Impedance (biased at 5.5V with a 50mV test signal)

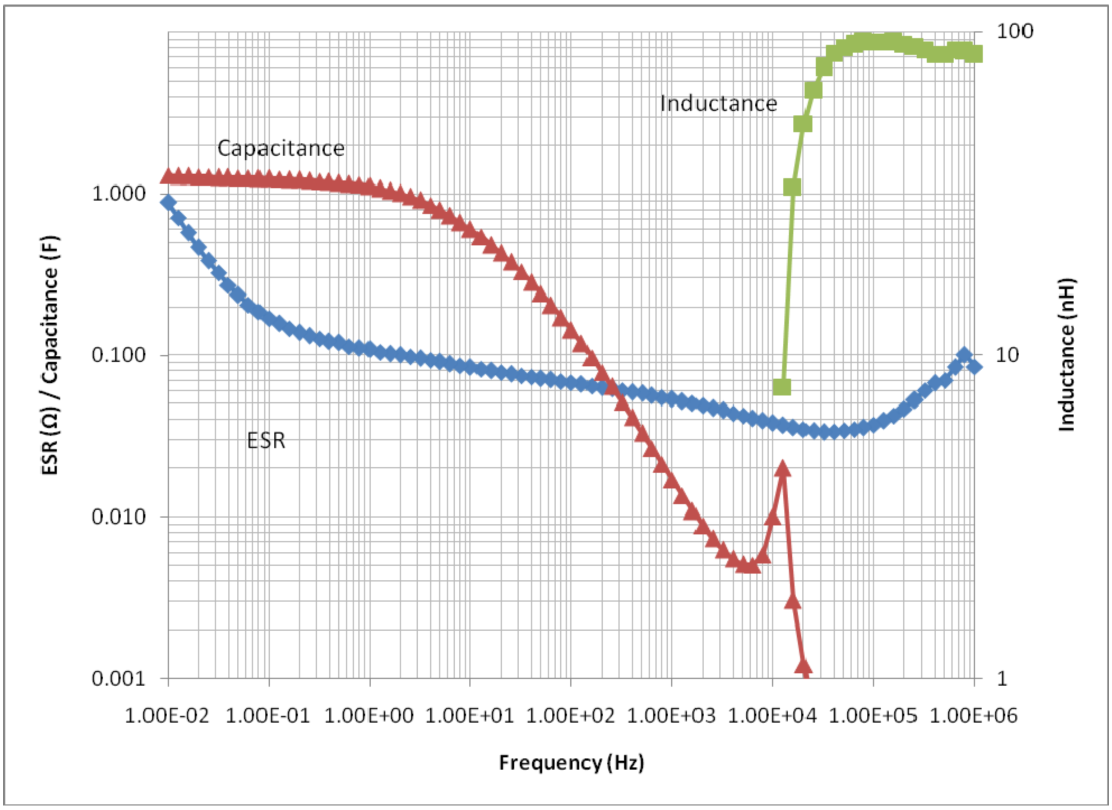

Figure 9: Frequency Response of ESR, Capacitance and Inductance

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Fig 8 shows the supercapacitor behaves as an ideal capacitor until approx 2Hz when the magnitude no longer rolls off proportionally to 1/freq and the phase crosses -45°. Performance of supercapacitors with frequency is complex and the best predictor of performance is figure 5 which shows the effective capacitance as a function of pulse width. Inductance becomes significant above 10kHz where it is approximately 10nH. The HS230 is self resonant in the 7kHz range.

Spice Model

Please refer to www.cap-xx.com for a SPICE model of our supercapacitors. Note that the spice model predicts freq and pulse response, not leakage current over the first 120hrs, prior to equilibrium being reached.

Leakage Current

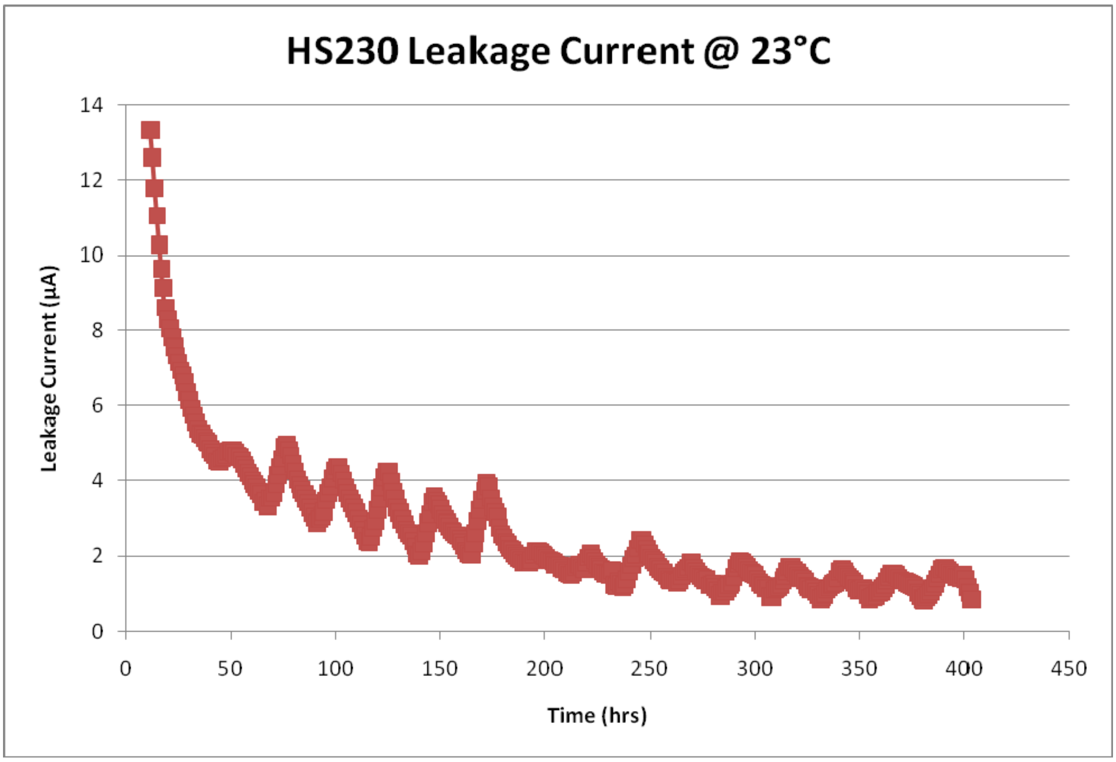

Figure 10: Average leakage current @ 23°C, 5.5V

Figure 10 shows how average leakage current decays with time. After 24hrs @ 23°C, leakage current has decayed to approx 7µA and after 72hrs it has decayed to less than 5µA. This is because the capacitance in a supercapacitor is distributed. This means that although the final terminal voltage has been reached, the device still draws some charge current which continues to decay until it reaches a final equilibrium value of leakage current. At 50°C, leakage current is approximately double the leakage current at 23°C.

Charge Current

Supercapacitors require a minimum charge current before they behave as expected, i.e. they follow $\Delta V = I \times \Delta t / C$, for constant current charging from 0V. For the HS230 this minimum charge current is 50µA. Figure 11 illustrates the voltage over time for a single cell of the HS230 using 500µA, 200µA, 100µA and 50µA to achieve a final voltage of 2. 5V. Note that the minimum charge current at which charging follows $\Delta V = I \times \Delta t/C$ is 100µA.

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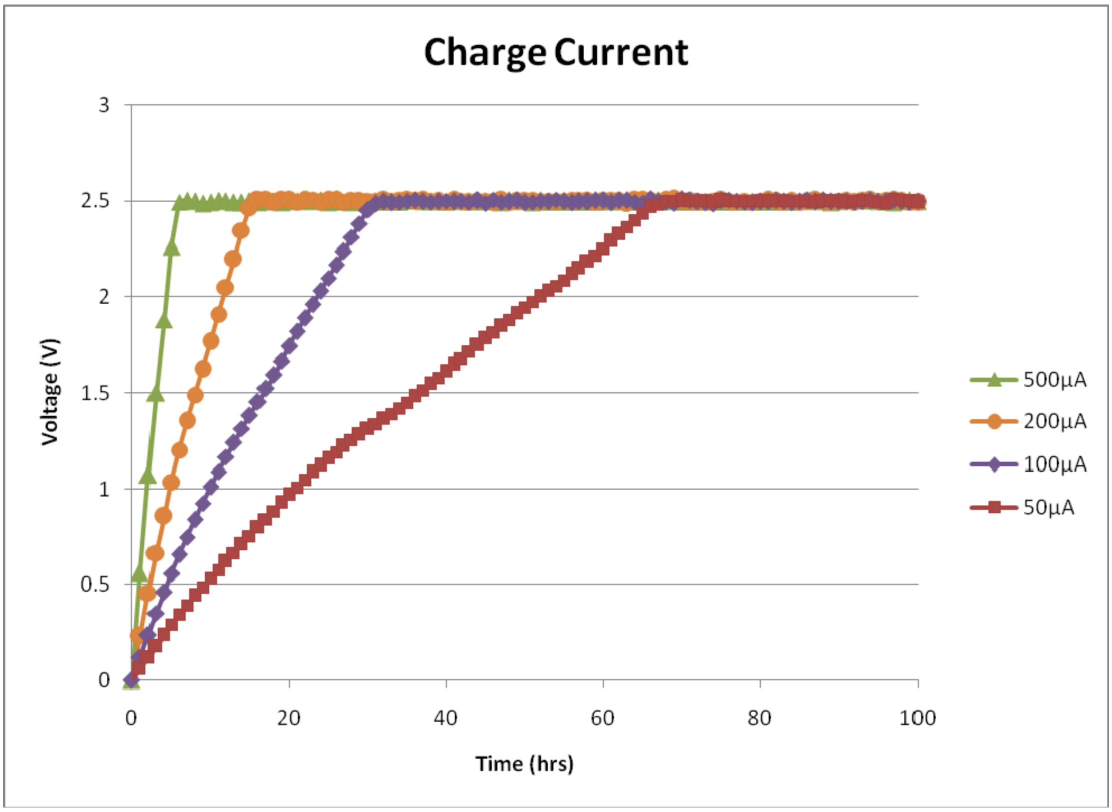

Figure 11: Voltage vs. Time for 500µA, 200µA, 100µA and 50µA Charge Currents at 23°C

Soldering

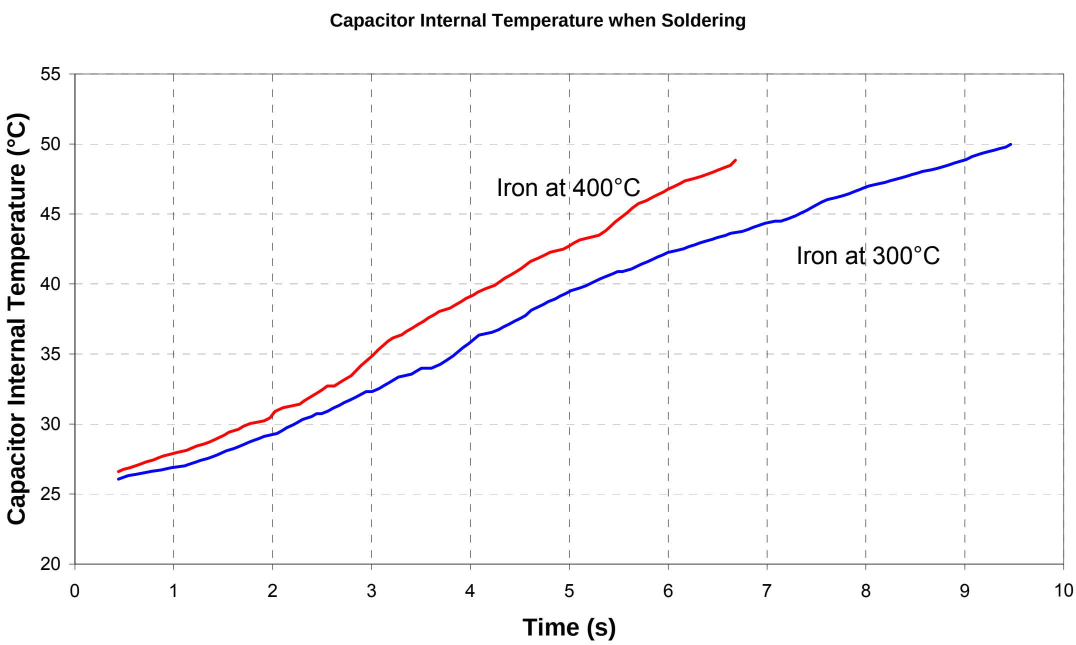

Figure 12: Capacitor temperature rise when soldering

The recommended maximum soldering time is 5 seconds when using an iron at 400°C in an ambient temperature of 25°C. Fig 12 shows the internal temperature of the supercapacitor over time when a soldering iron at 400°C is applied to one terminal.

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Vibration

Tested to IEC68-2-6

Type	Sinusoidal
Frequency	55Hz-500Hz
Amplitude	0.35mm±3dB (55Hz to 59.55Hz)
	5g±3dB (59.55Hz to 500Hz)
Sweep Rate	1 Oct/min
No. of Cycles	10 (55Hz-500Hz-50Hz)
No. of Axis	3 orthogonal
Results	No electrical or mechanical degradation (adhesive not required)

Shock

Tested to IEC68-2-27

Pulse Shape	Half Sine
Amplitude	30g±20%
Duration	18ms±5%
No. of Shocks	3 in each direction (18 in total)
No. of Axis	3 orthogonal
Results	No electrical or mechanical degradation (adhesive not required)

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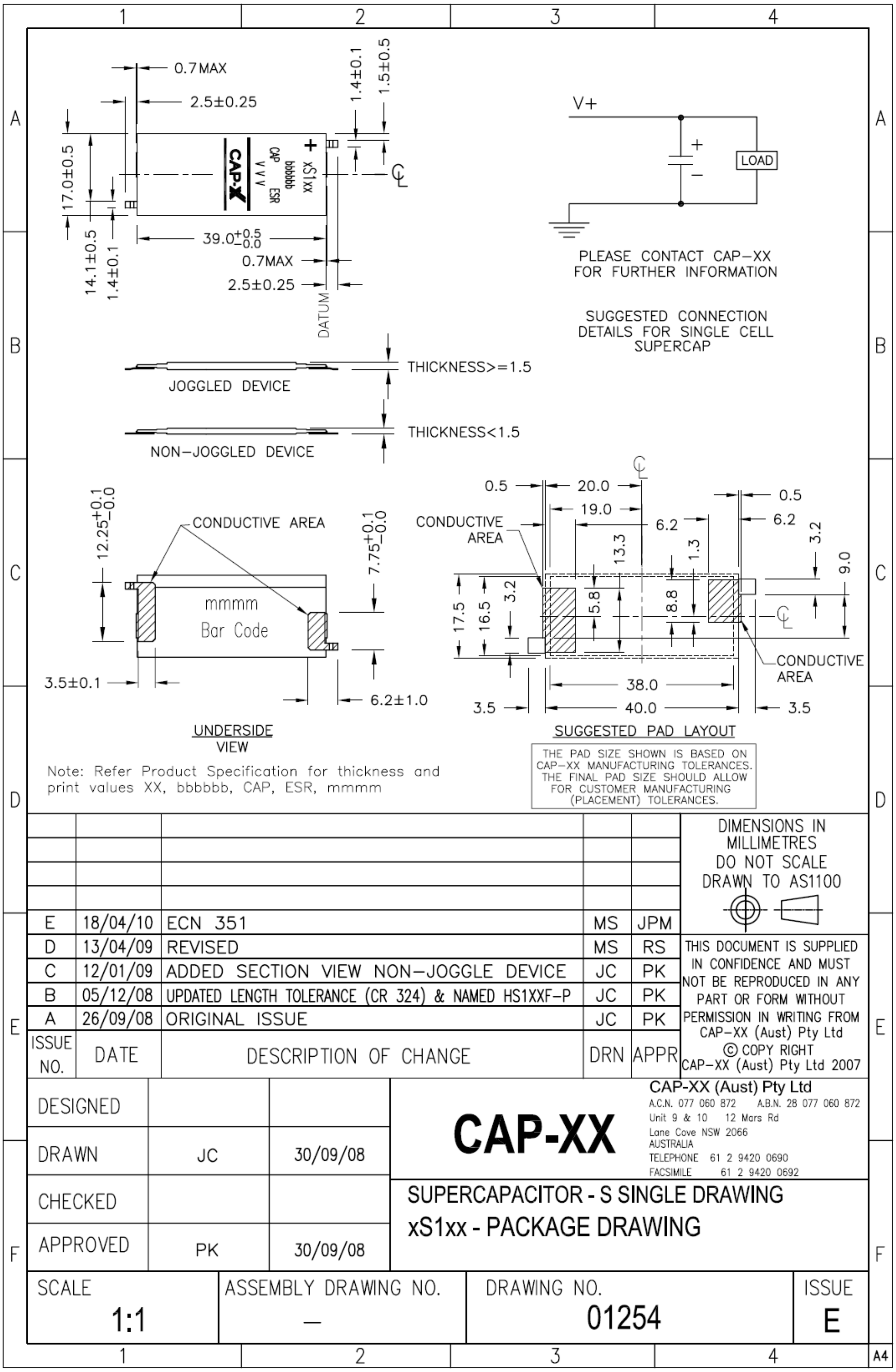

Fig 13: HS130 Mechanical drawing

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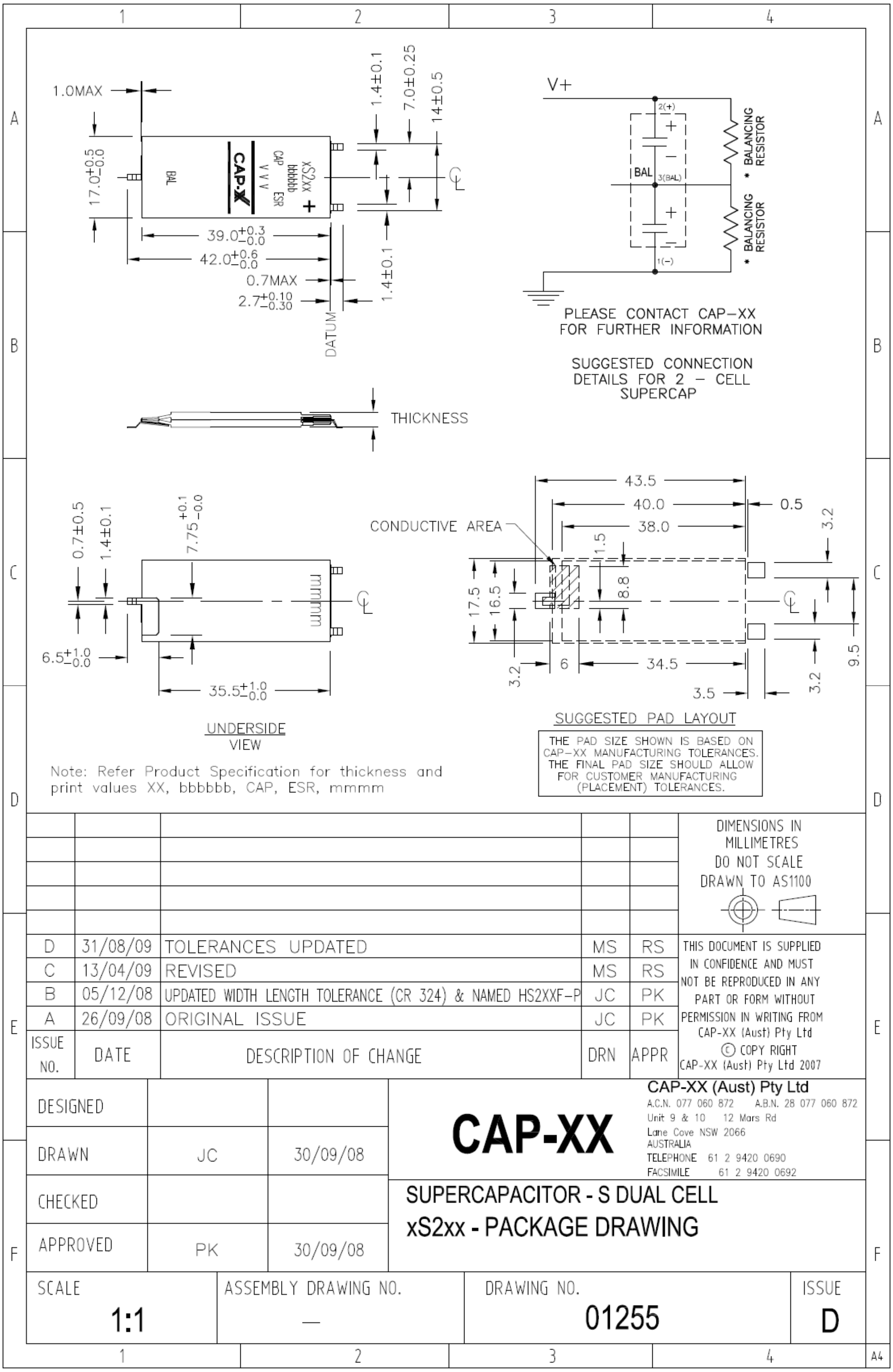

Fig 14: HS230 Mechanical drawi

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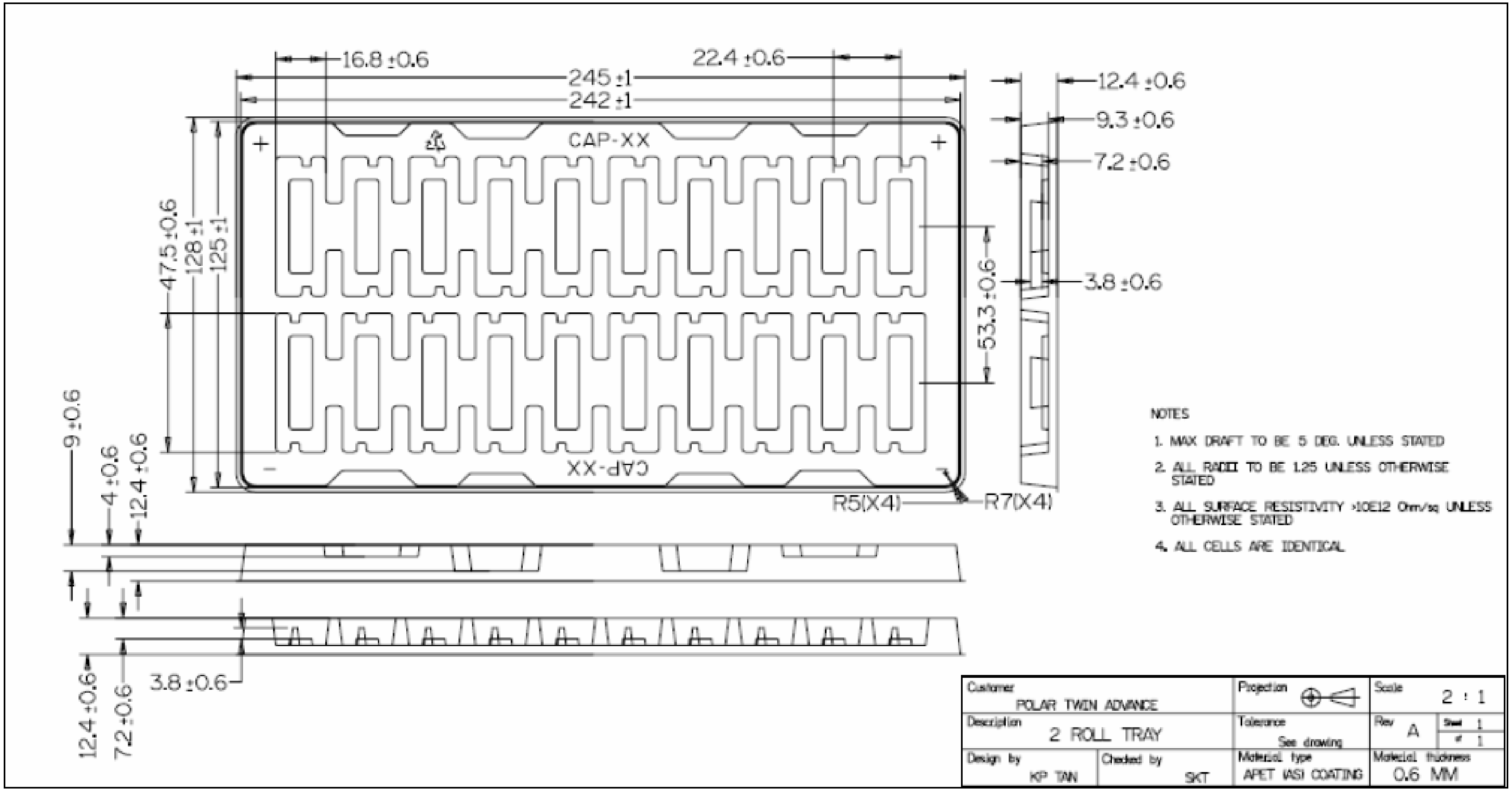

Figure 14: Packaging Tray

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